Wind Energy Update

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National Renewable Energy Laboratory

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Sizes and Applications

Small (≤10 kW)

- Homes
- Farms
- Remote Application

Intermediate (10-250 kW)

- Village Power
- Hybrid Systems
- Distributed Power

Large (660 kW - 2+MW)

- Central Station Wind Farms
- Distributed Power
- Community Wind

The Evolution of Commercial U.S. Wind Technology

NREL

Rotor Diameter in meters

100
80
60
40
20
0

1980
1990
2000
2010

1980s

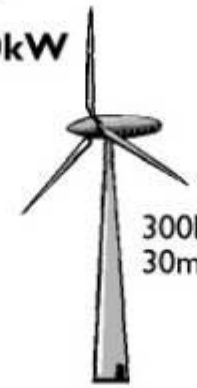
- Structurally stiff
- 3 bladed – upwind yaw-driven
- Constant speed and 2 speed
- Stall regulated/tip brakes or full-span pitch controlled
- Fiberglass blades
- Geared transmission
- Induction generator
- Steel truss or tube tower

50 - 300kW
15m - 30m diameter

50kW
100kW
300kW
500kW
750kW
1.8MW
5MW
Forecast

1990s

- Structurally stiff
- 3 bladed – upwind yaw-driven
- Variable speed and constant speed
- Special airfoils – NREL
- Stall regulated and pitch controlled
- Planetary transmission
- Induction generator
- Large size to reduce COE



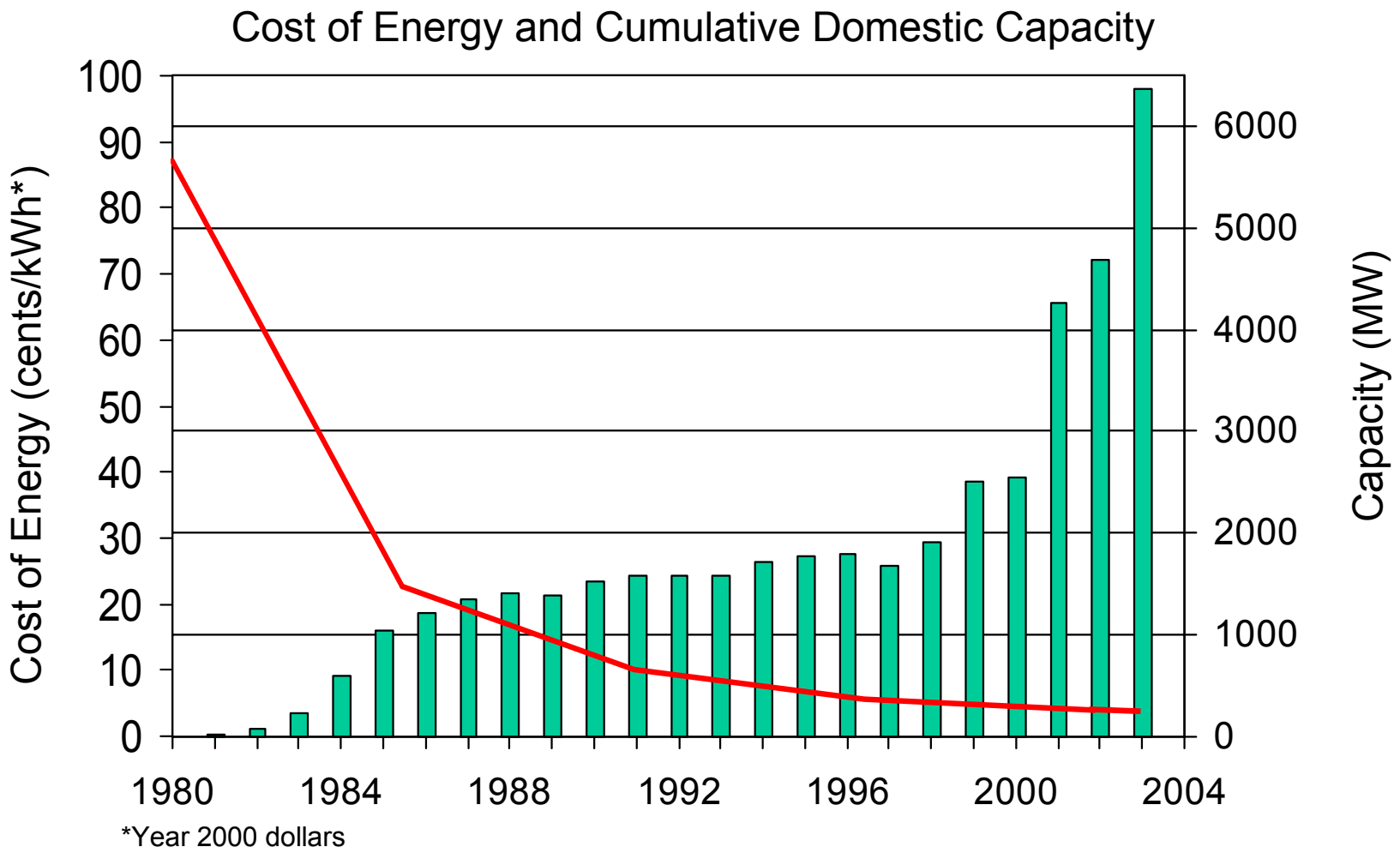
300kW - 750kW
30m - 50m diameter

Future Innovation

- Scale to larger size
- Advanced blade materials and manufacturing
- Low speed direct drive generators
- Custom power electronics (high efficiency)
- Feedback control of drive train and rotor loads
- More flexible structurally
- O&M reduction features

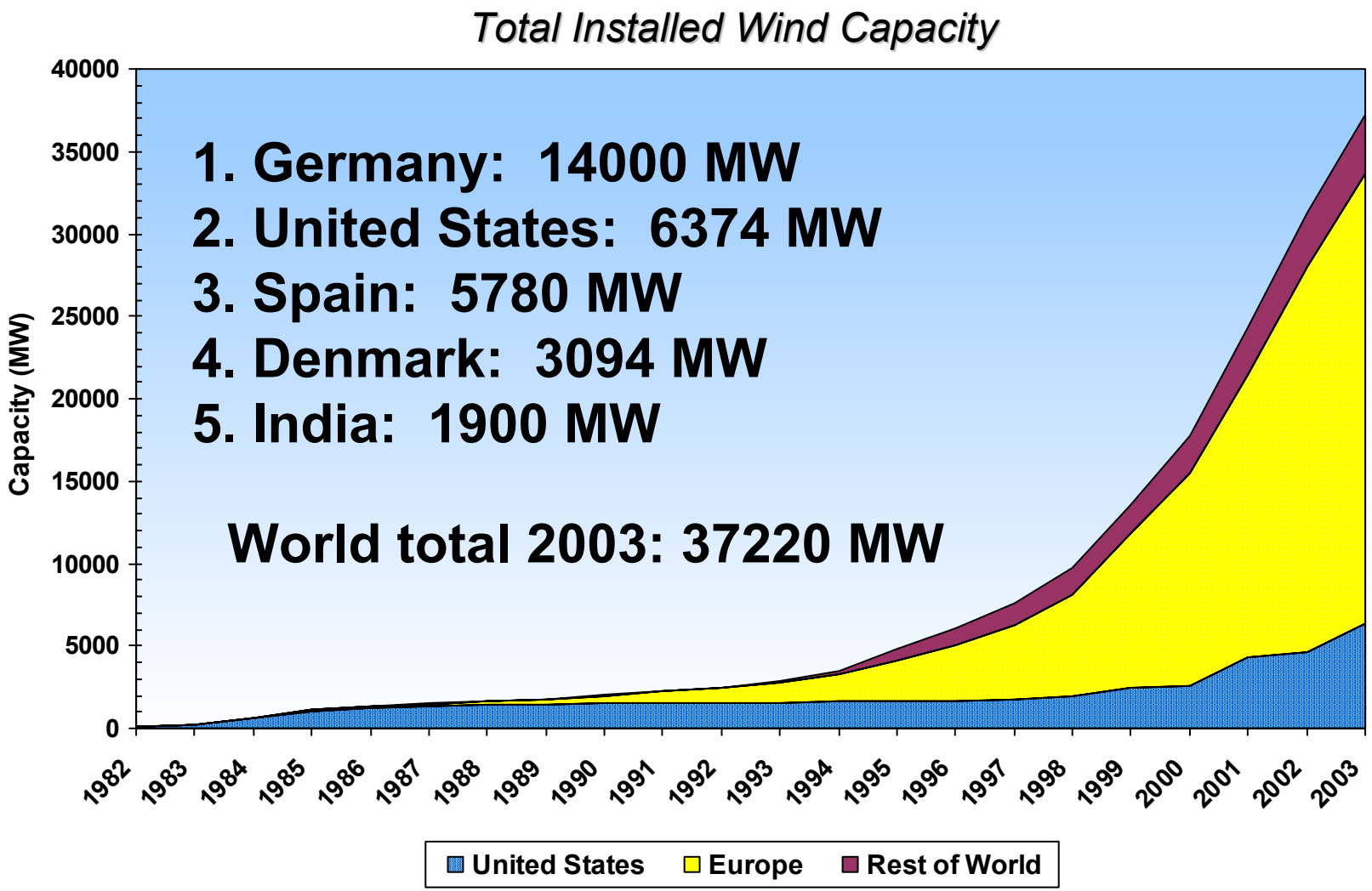
Source: Thresher & Dodge, Wind Energy Journal 1998

Capacity & Cost Trends



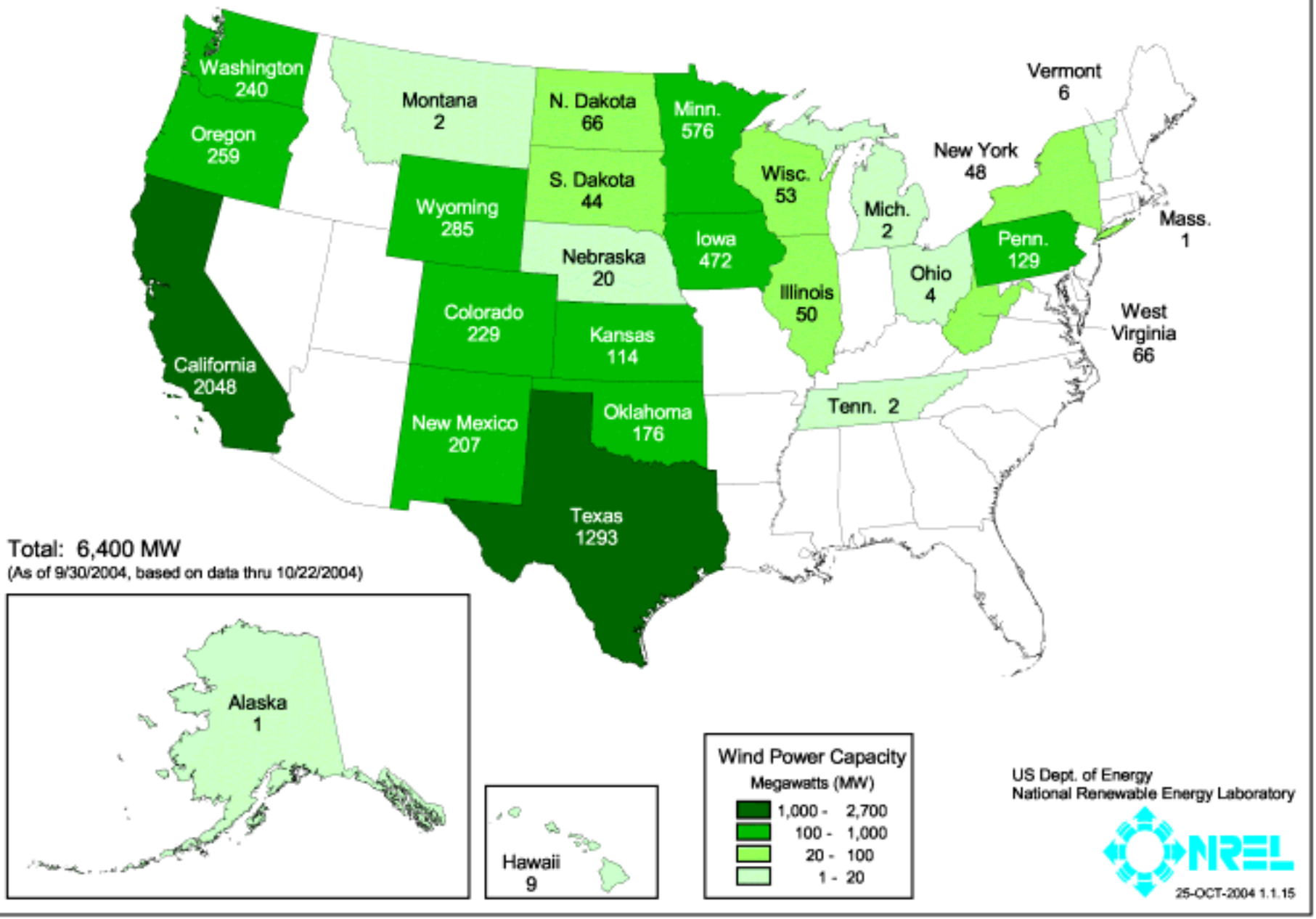
Increased Turbine Size - R&D Advances - Manufacturing Improvements

World Growth Market



Source: WindPower Monthly

United States - Wind Power Capacity (MW)



Total: 6,400 MW

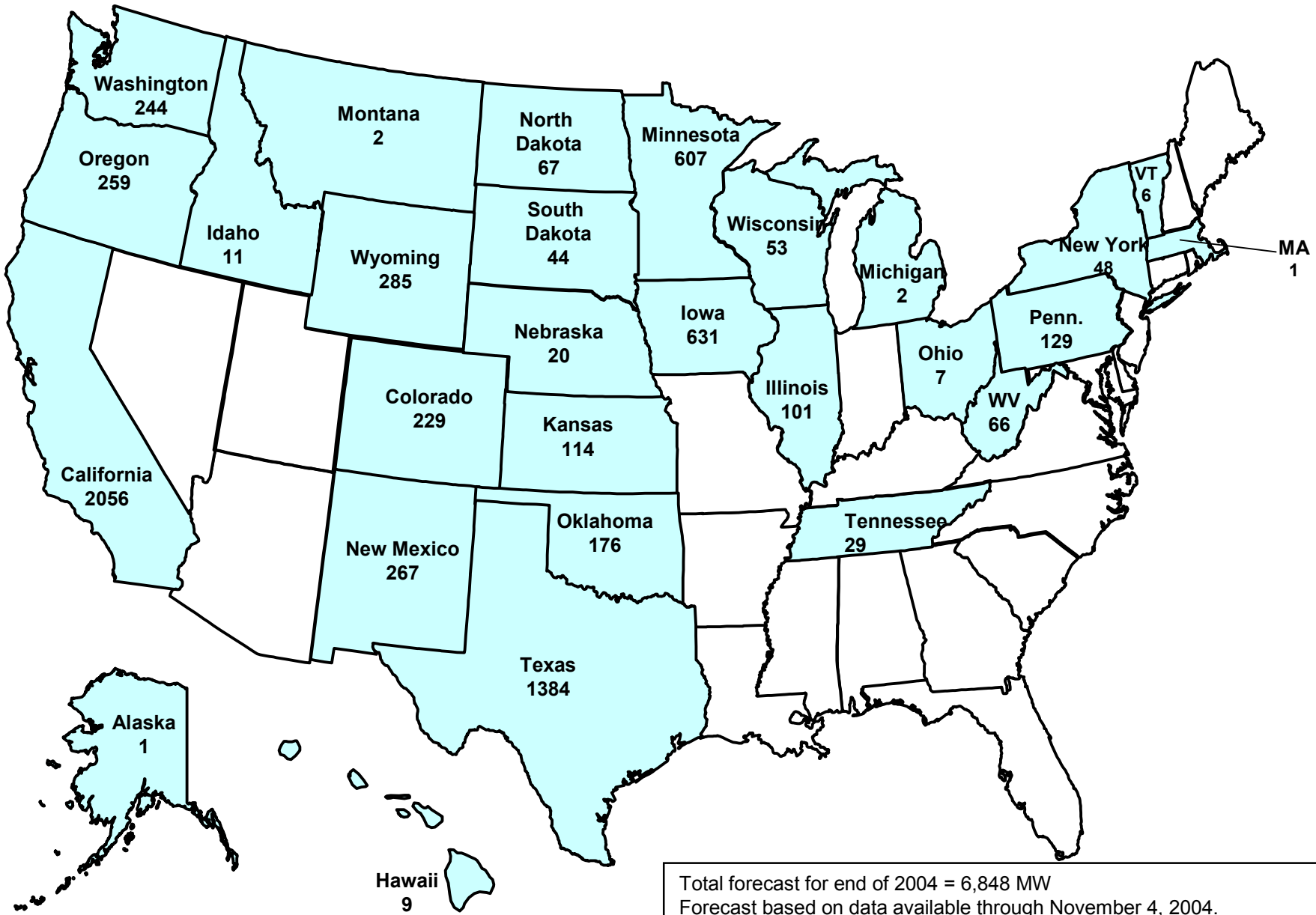
(As of 9/30/2004, based on data thru 10/22/2004)

US Dept. of Energy
National Renewable Energy Laboratory

NREL

25-OCT-2004 1.1.15

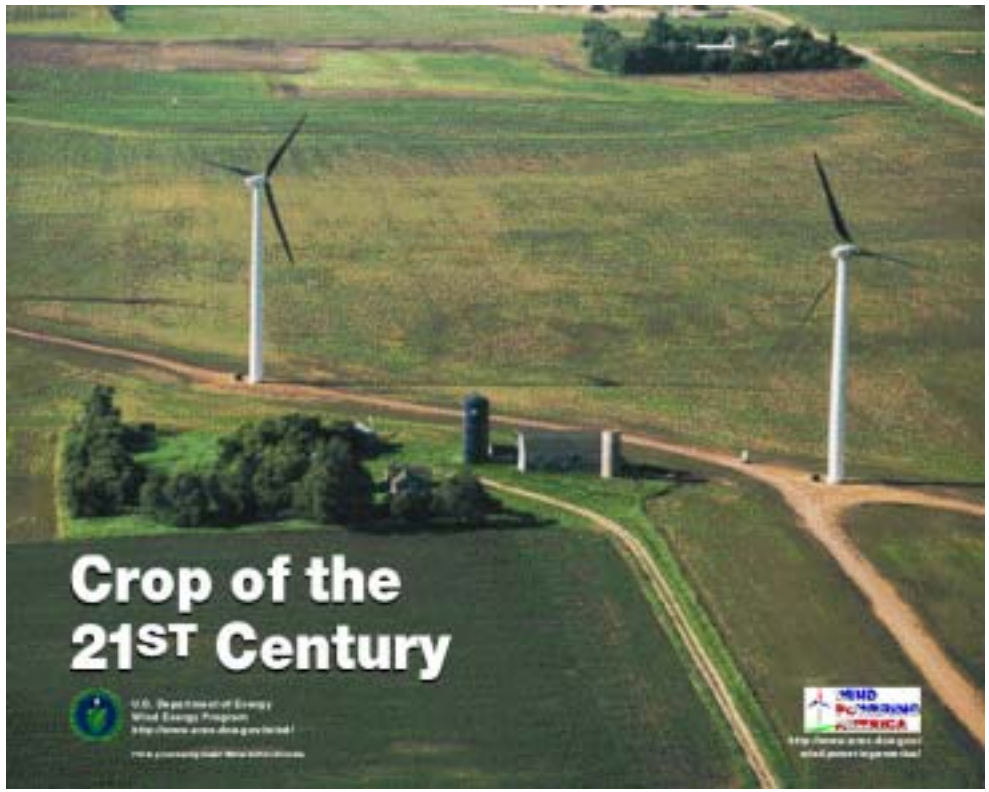
Projected Megawatts of Installed Utility-Scale Wind Power, End of 2004



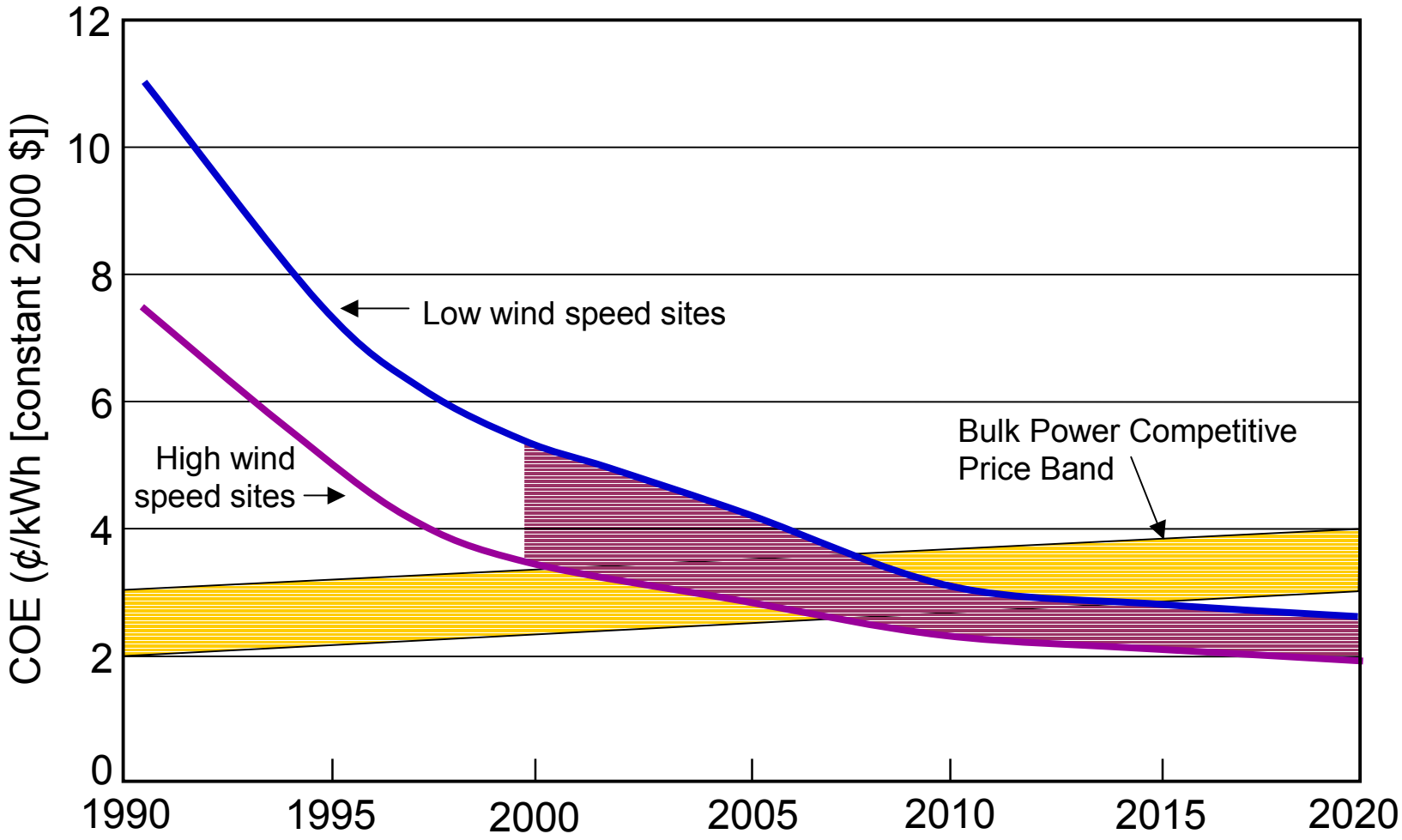
Total forecast for end of 2004 = 6,848 MW
Forecast based on data available through November 4, 2004.
Blank indicates no utility-scale installations or less than 1 MW of installations.

Drivers for Wind Power

- Declining Wind Costs
- Fuel Price Uncertainty
- Federal and State Policies
- Economic Development
- Green Power
- Energy Security

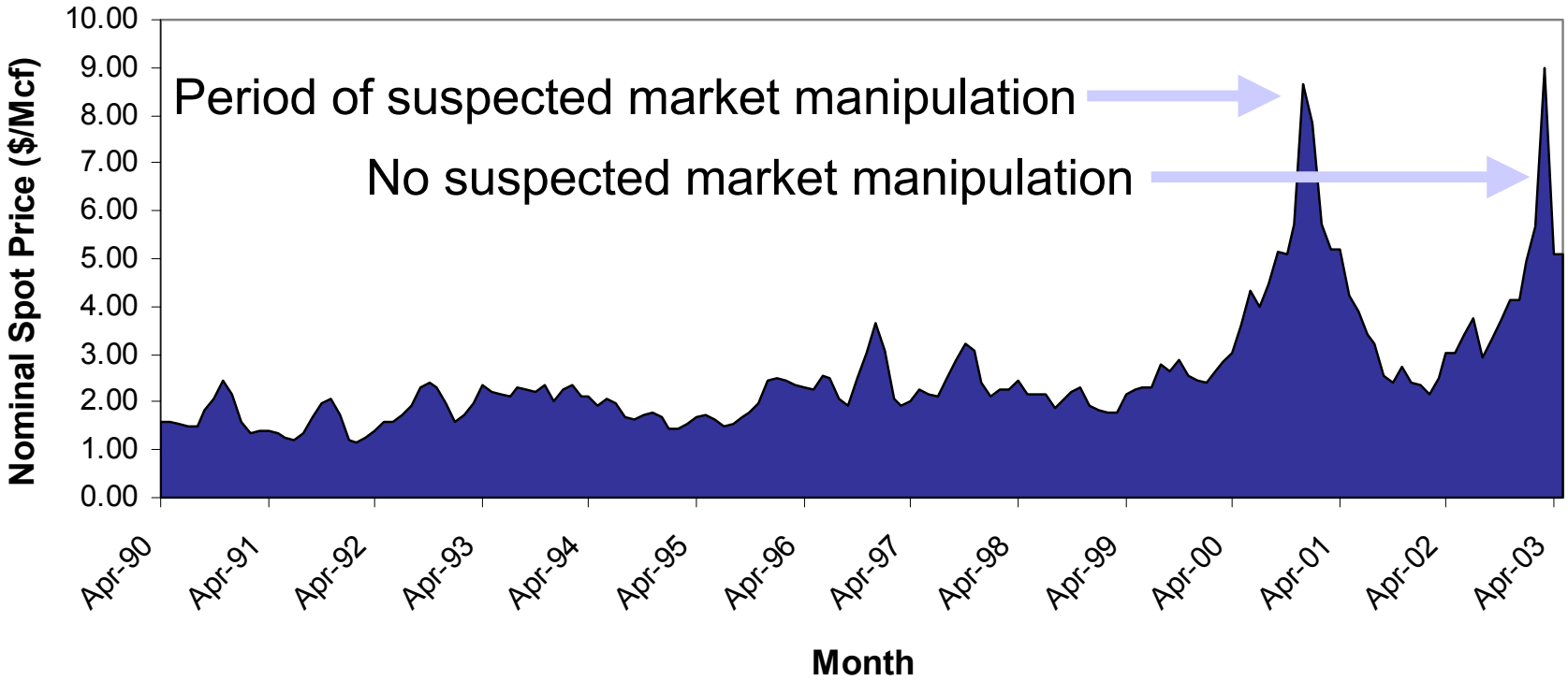


Wind Cost of Energy



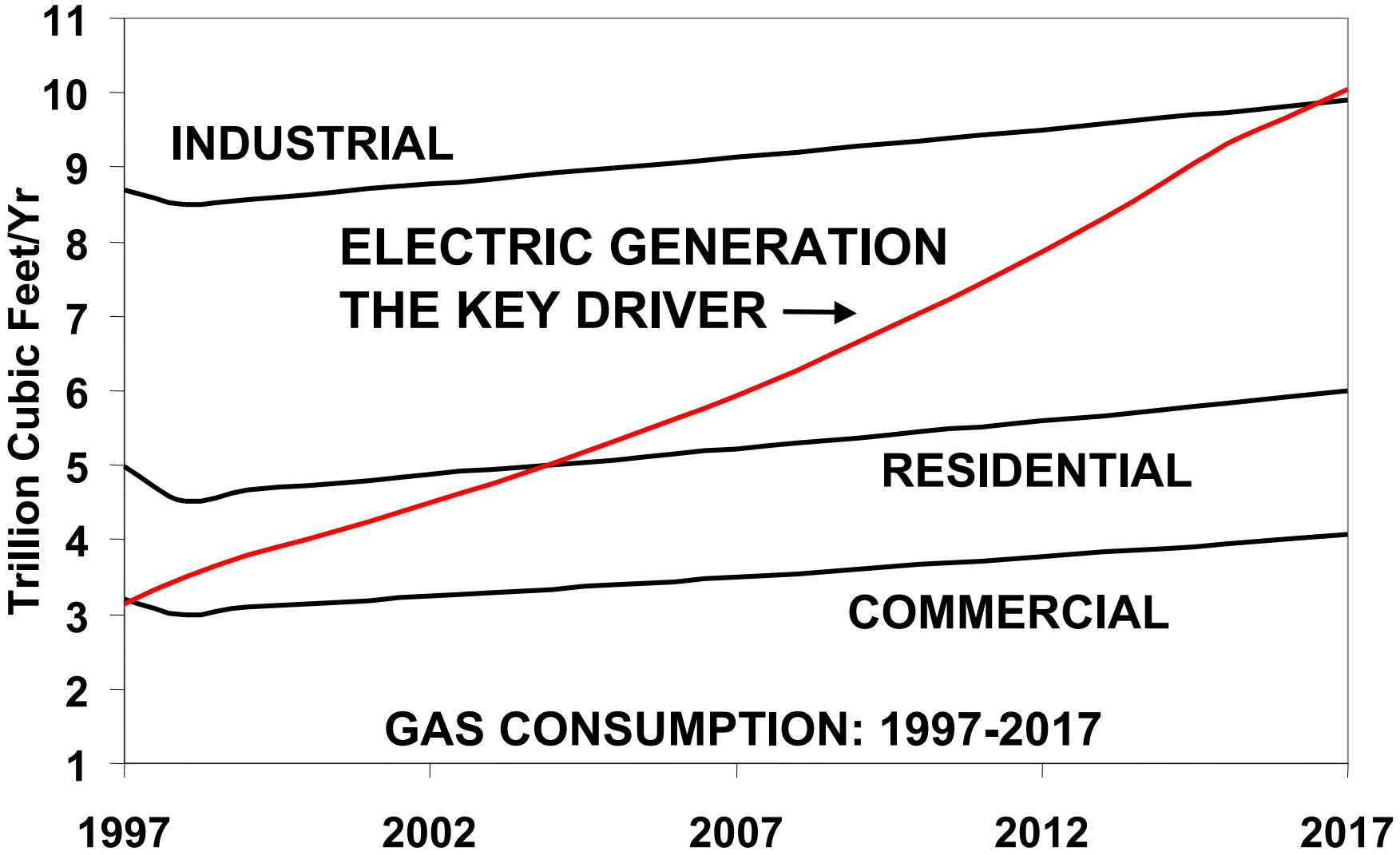
Volatile Natural Gas Prices

(Spot Prices 1990-2003)

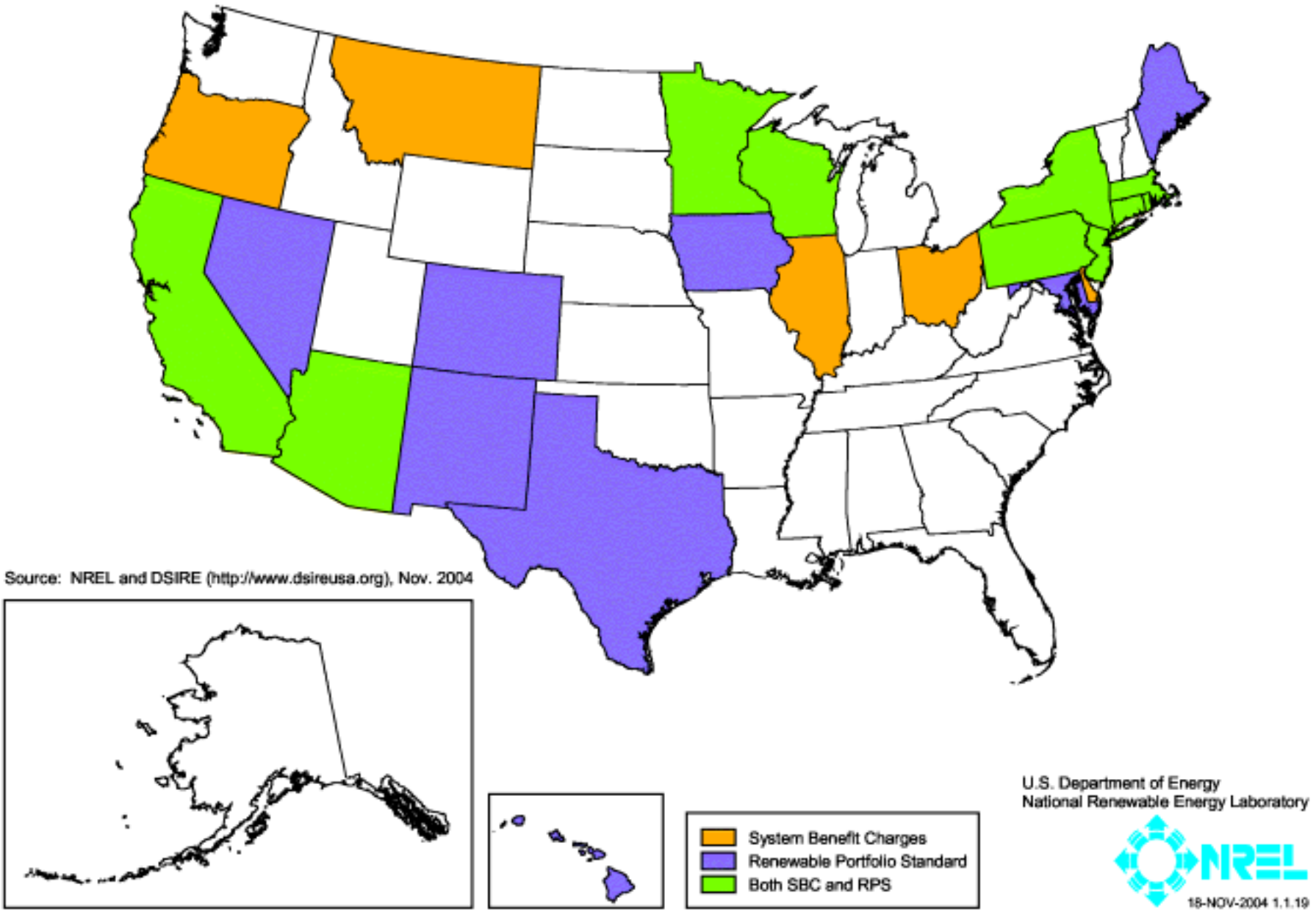


Source: NYMEX; Institute for Energy, Law & Enterprise, 2003

The "Dash to Gas"



United States - States with Renewable Energy Policies



Source: NREL and DSIRE (http://www.dsireusa.org), Nov. 2004

U.S. Department of Energy
National Renewable Energy Laboratory

NREL

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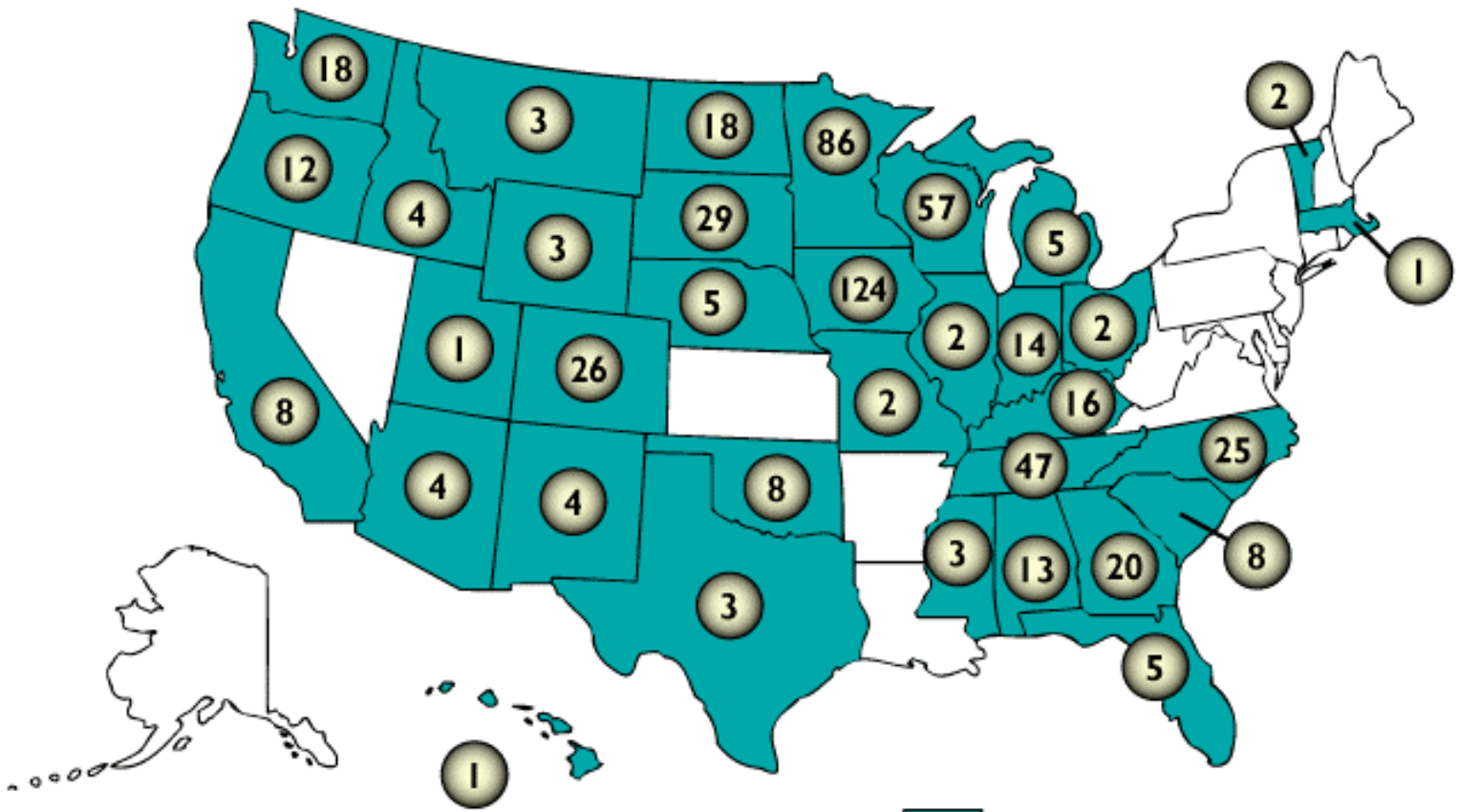
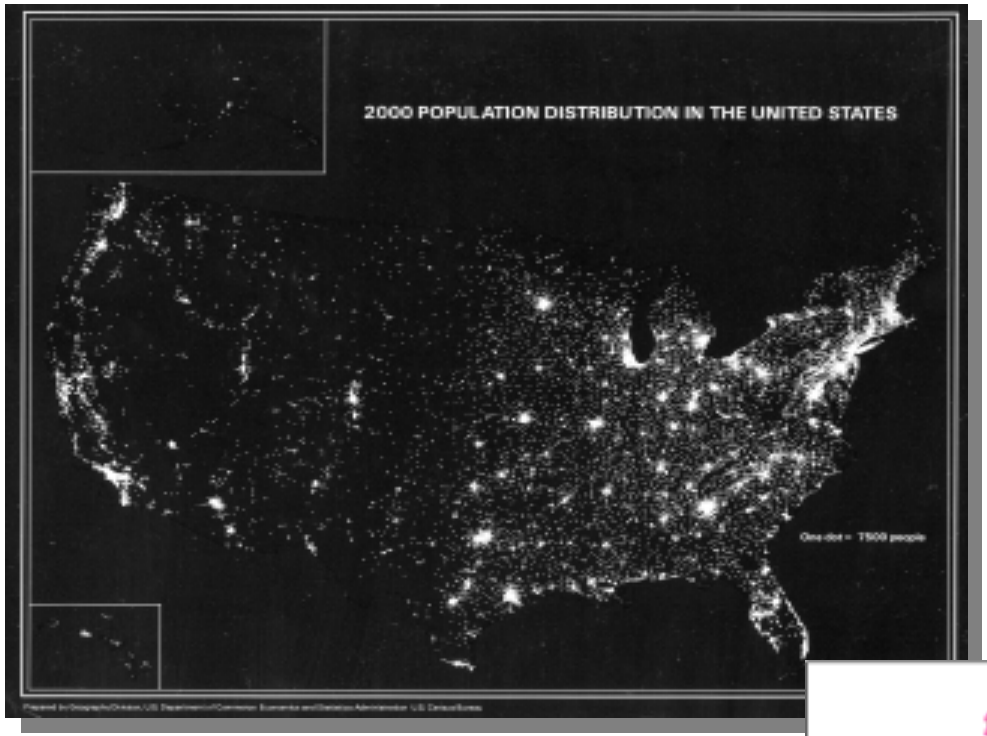
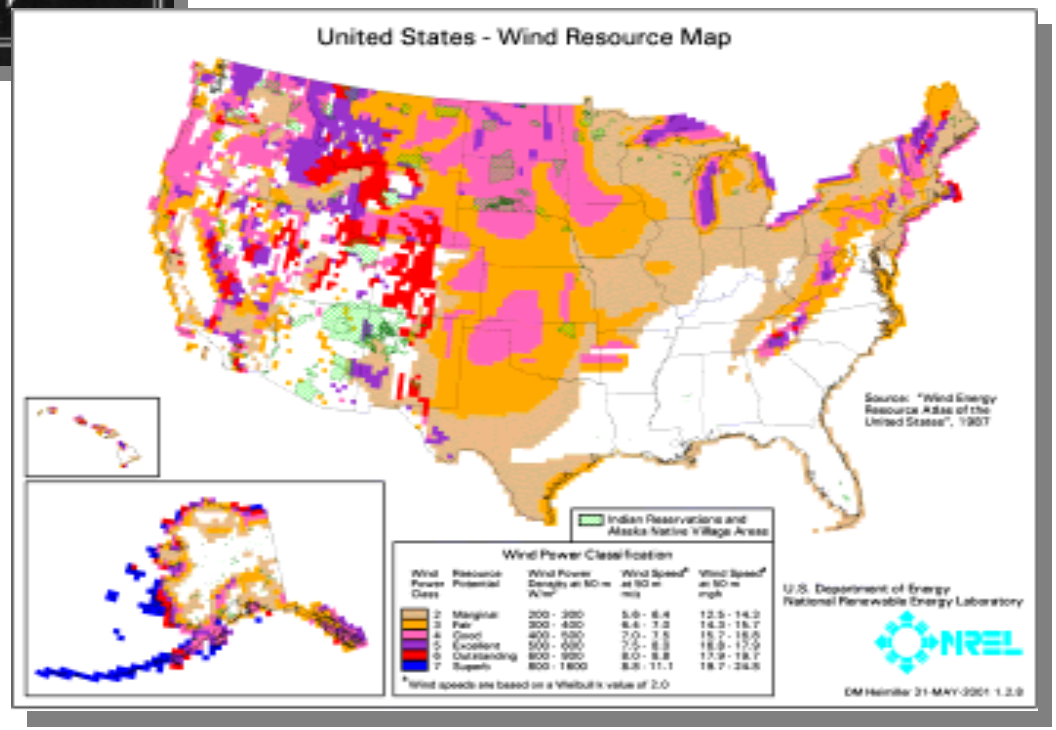
Utility Green Pricing Activities



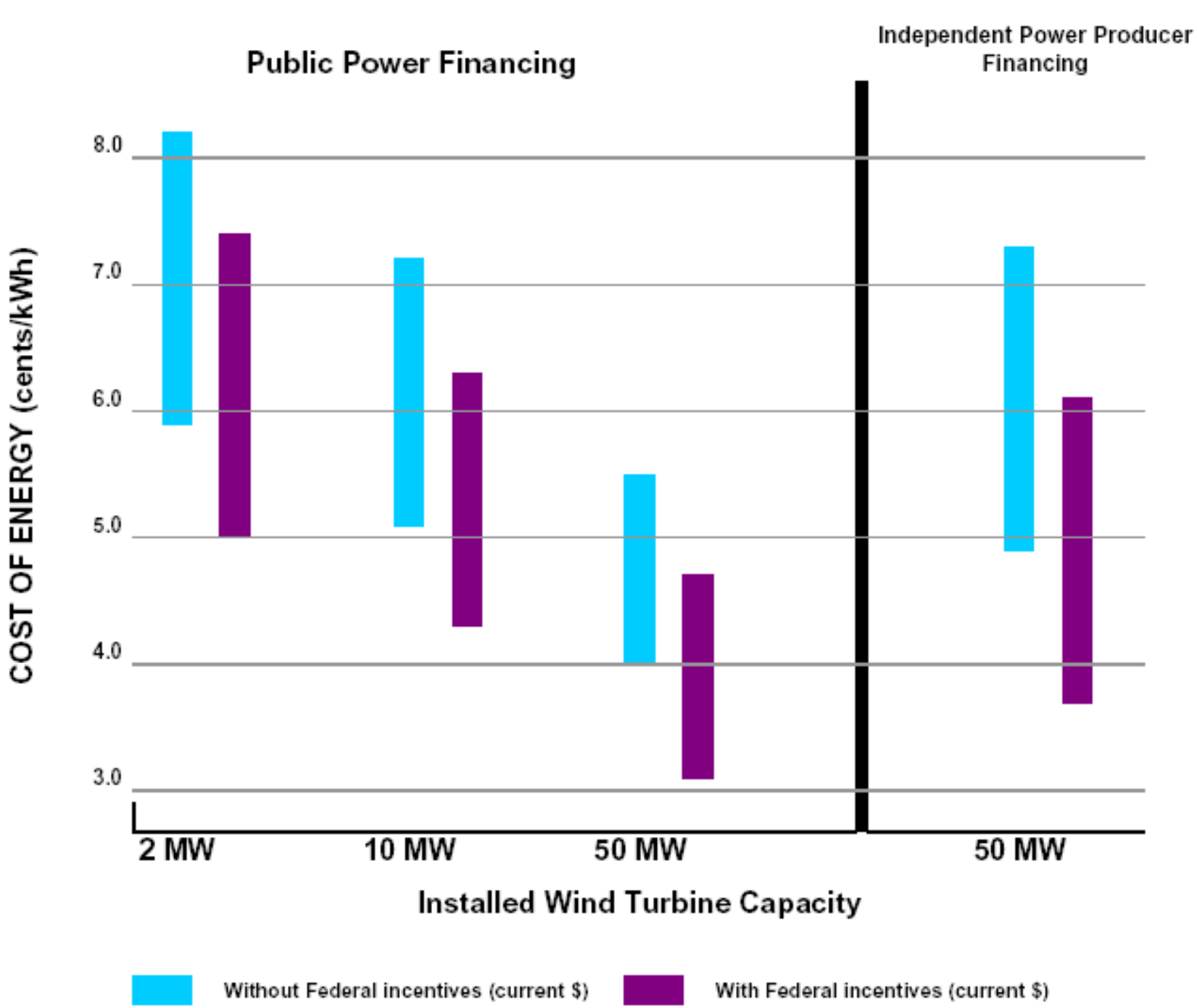
Source: National Renewable Energy Laboratory (September 2004)


2000 POPULATION DISTRIBUTION IN THE UNITED STATES
One dot = 7500 people

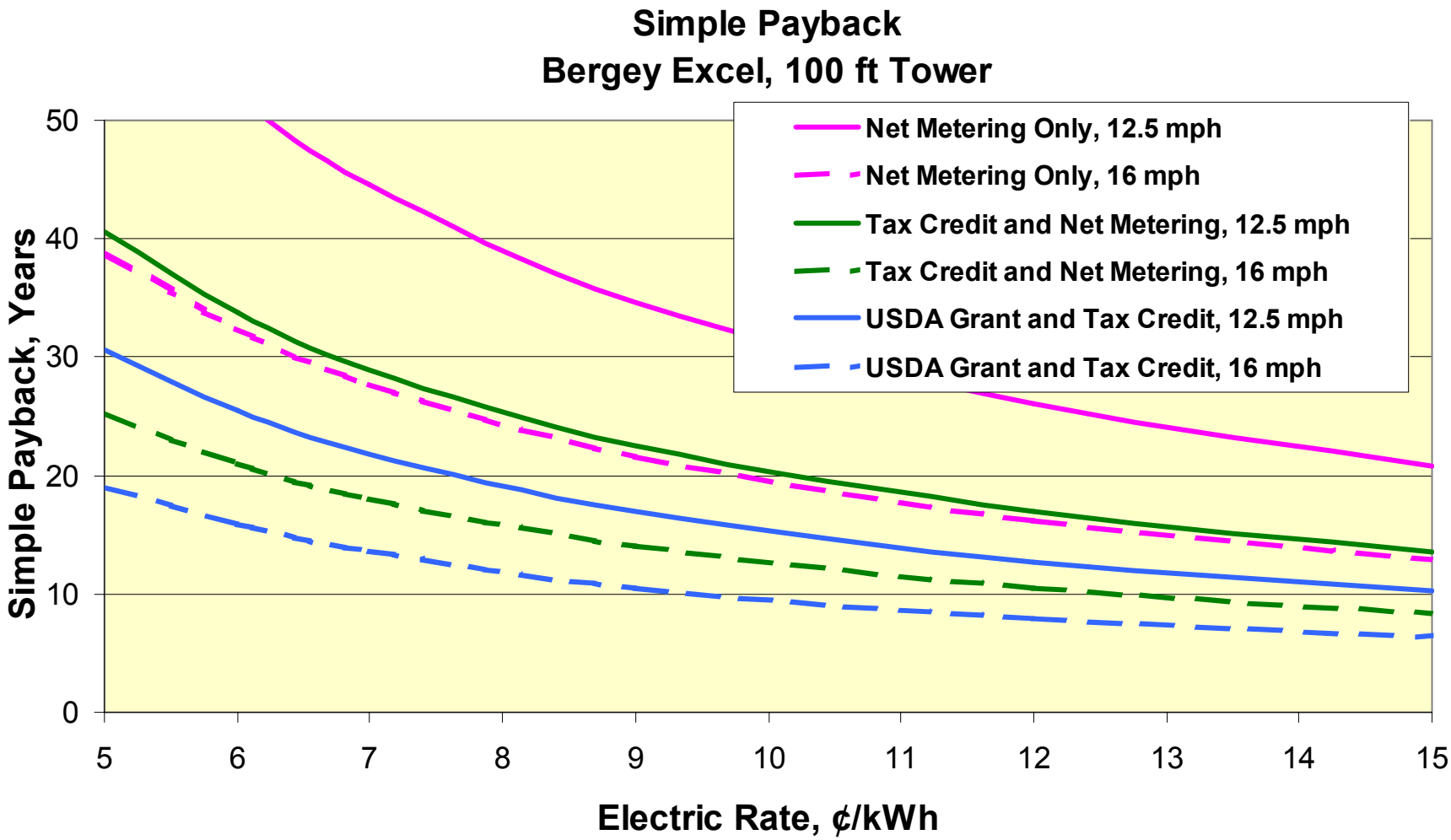

United States - Wind Resource Map
Source: "Wind Energy Resource Atlas of the United States", 1987
Indian Reservations and Alaska Native Village Areas
Wind Power Classification
Wind Power Class
Resource Potential
Wind Power Density at 50 m W/m²
Wind Speed* at 50 m m/s
Wind Speed* at 50 m mph
2 Marginal 200 - 300 5.9 - 6.4 13.3 - 14.3
3 Fair 300 - 400 6.4 - 7.0 14.3 - 15.7
4 Good 400 - 500 7.0 - 7.5 15.7 - 16.8
5 Excellent 500 - 600 7.5 - 8.0 16.8 - 17.9
6 Outstanding 600 - 800 8.0 - 8.8 17.9 - 19.7
7 Superb 800 - 1600 8.8 - 11.1 19.7 - 24.8
*Wind speeds are based on a Weibull k value of 2.0
U.S. Department of Energy
National Renewable Energy Laboratory
NREL
DM Heimiller 31-MAY-2001 1.2.0

Wind Economics – Determining Factors

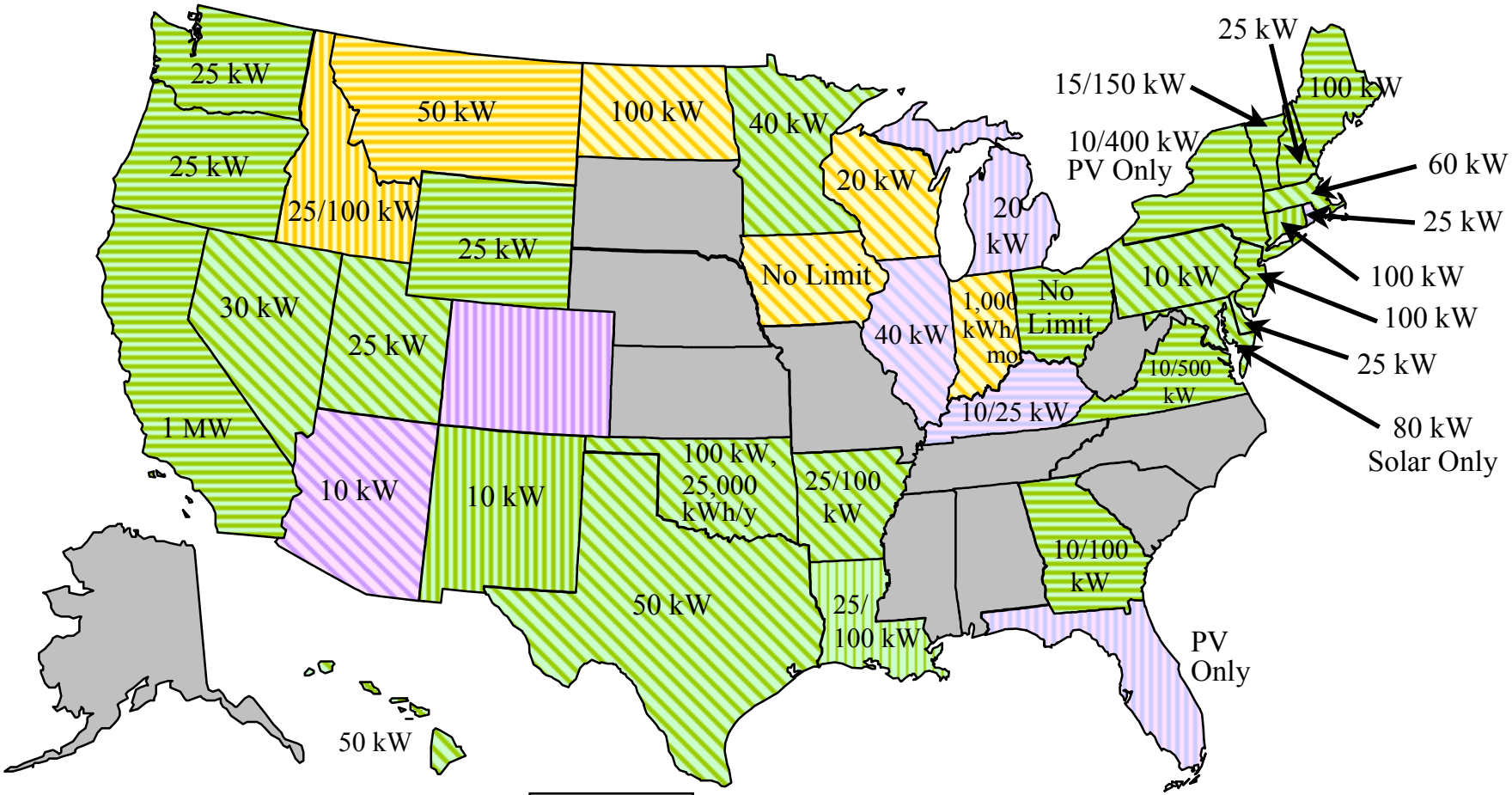
- Wind Resource
- Financing and Ownership Structure
- Taxes and Policy Incentives
- Plant Size: equipment, installation and O&M economies of scale
- Turbine size, model, and tower height
- Green field or site expansion
- What is included: land, transmission, ancillary services


Public Power Financing
Independent Power Producer Financing
COST OF ENERGY (cents/kWh)
8.0
7.0
6.0
5.0
4.0
3.0
2 MW
10 MW
50 MW
50 MW
Installed Wind Turbine Capacity
Without Federal incentives (current $)
With Federal incentives (current $)

Small Wind Economics



Net Metering by State



Revised: 9Jul04

Economic Development Impacts

- **Land Lease Payments**: 2-3% of gross revenue $2500-4000/MW/year
- **Local property tax** revenue: 100 MW brings in on the order of $500,000 - 1 million/yr
- 1-2 **jobs**/MW during construction
- 2-5 permanent O&M **jobs** per 50-100 MW
- Local construction and service industry: concrete, towers usually done locally
- Investment as equity owners: production tax credit, accelerated depreciation

Wind Power Provides Rural Economic Benefits

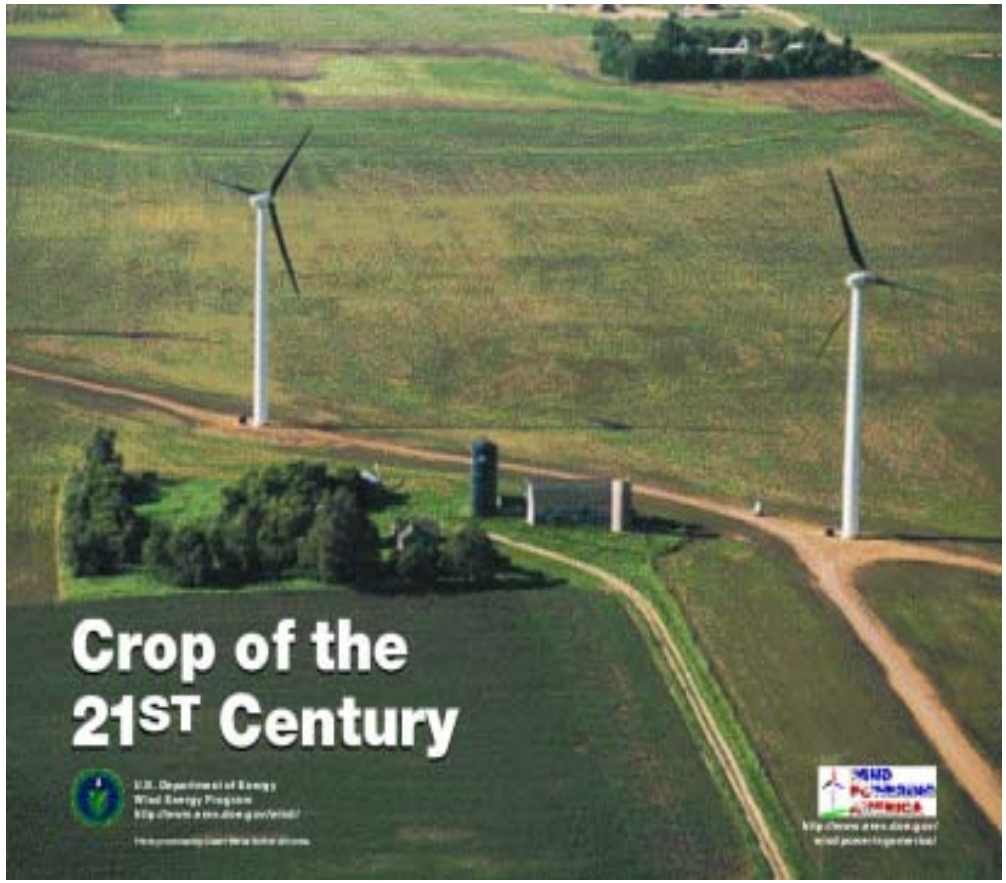
- *240 MW of wind in Iowa*
  - $640,000/yr in **lease payments** to farmers ($2,000/turbine/yr)
  - $2 million/yr in **property taxes**
  - $5.5 mil/yr in O&M **income**
  - 40 long-term O&M jobs
  - 200 short-term construction jobs
  - doesn't include multiplier effect
- *107 MW wind project in MN*
  - $500,000/yr in **lease payments** to farmers
  - $611,000 in **property taxes** in 2000 = 13% of total county taxes
  - 31 long-term local jobs and $909,000 in **income** from O&M (includes multiplier effect)

Wind Power Provides Rural Economic Benefits

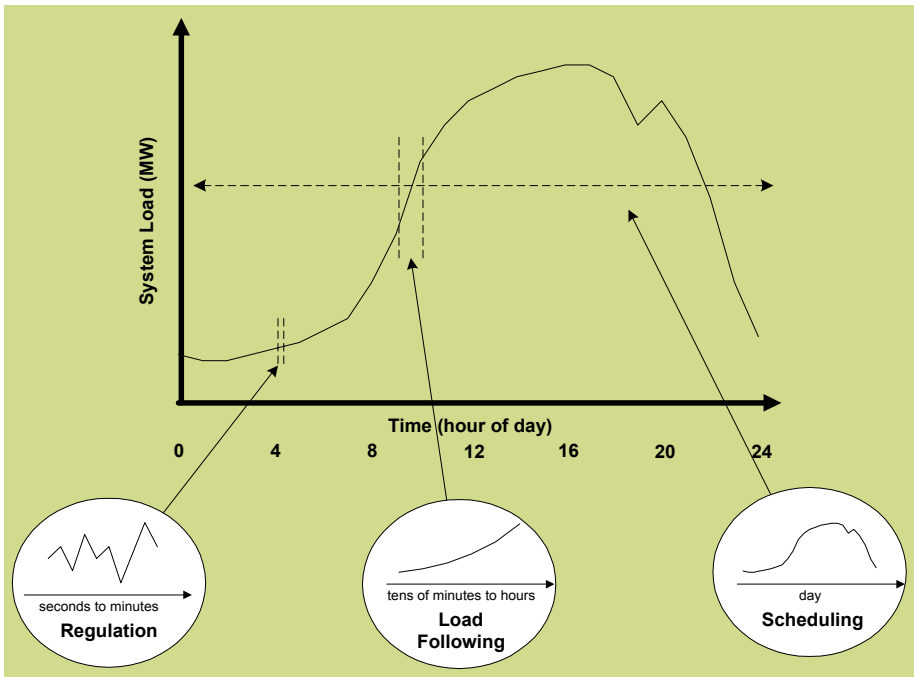
- *40 MW of wind in South Dakota* = $400,000 - $450,000/yr for Hyde County, including:
  - More than $100,000/yr in annual **lease payments** to farmers ($3,000 - $4,000/turbine/yr)
  - $250,000/yr in **property taxes** (25% of Highmore's education budget)
  - 75 -100 construction **jobs** for 6 months
  - 5 permanent O&M **jobs**
  - Sales taxes up more than 40%
  - Doesn't include multiplier effect

Key Issues for Wind Power

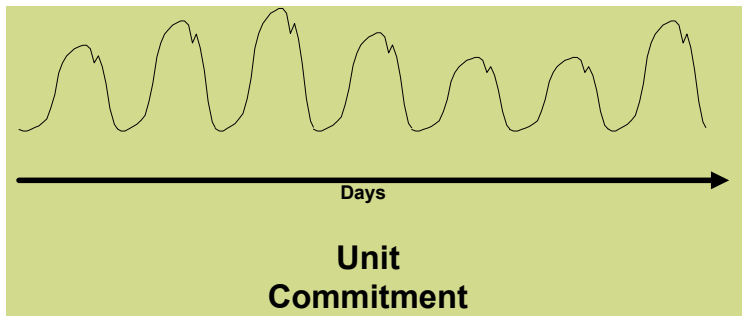
- Policy Uncertainty
- Siting and Permitting: avian, noise, visual, federal land
- Transmission: access, RTO formation and rules, new lines
- Operational impacts: intermittency, ancillary services, allocation of costs
- Accounting for non-monetary value: green power, no fuel price risk, reduced emissions



Power-System Operation Impacts



- Regulation -- seconds to a few minutes -- similar to variations in customer demand (loads)
- Load-following -- tens of minutes to a few hours -- usage follows predictable patterns, wind less so



- Scheduling and commitment of generating units -- one to several days -- wind impacts unclear

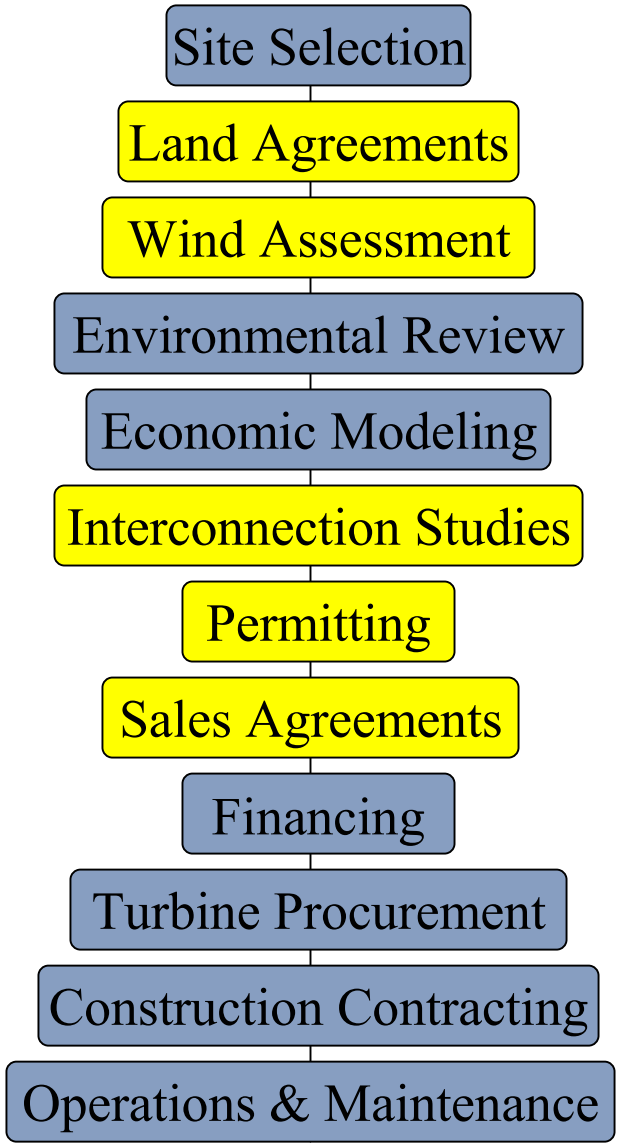
Wind controlled by nature, not power-plant operators!

Ancillary Services Cost Comparison

Source: UWIG

		$/MWh			
Study	Relative Wind Penetration (%)	Regulation	Load Following	Unit Commitment	Total
UWIG/Xcel	3.5	0	0.41	1.44	1.85
PacifiCorp	20	0	2.50	3.00	5.50
BPA	7	0.19	0.28	1.00-1.80	1.47-2.27
Hirst	0.06-0.12	0.05-0.30	0.70-2.80	N/A	N/A
We Energies I	4	1.12	0.09	0.69	1.90
We Energies II	29	1.02	0.15	1.75	2.92
Great River Energy I	4.3				3.19
Great River Energy II	16.6				4.53

The Wind Project Development Process



Scott City, Kansas

- Turbine Size: 10 kW
- Turbine Manufacturer: Bergey WindPower
- Application: Grid-connected, supplements power supply for farm

Calverton, New York

- Turbine Size: 50 kW
- Turbine Manufacturer: Atlantic Orient Corp.
- Developer/owner: Long Island Power Authority
- Capacity: .050 MW

Spirit Lake, IA

Photo courtesy of AWEA

- Turbine: NEG Micon
- Size: 750 kw
- Owner: Spirit Lake Community Schools

Moorhead, Minnesota

- Turbine Size: 750 kW
- Turbine Manufacturer: NEG Micon
- Developer: Moorhead Public Service
- Capacity: .75 MW

Chamberlain, South Dakota

- Turbine Size: 1300 kW
- Turbine Manufacturer: Nordex
- Developer: Crown Butte Wind Power
- Capacity: 2.6 MW

Garrett, Pennsylvania

- Turbine Manufacturer: Nordex
- Developer: National Wind Power and Distributed Generation Systems, Inc.
- Capacity: 10.4 kW

Carbon County, Wyoming

- Turbine Size: 1 MW
- Turbine Manufacturer: Mitsubishi
- Developer/Owner: SeaWest Wind Power/Shell Renewables
- Capacity: 50 MW

Umatilla Oregon & Walla Walla County, Washington

- Turbine Size: 660 kW
- Turbine Manufacturer: Vestas
- Developer/Owner: FPL Energy
- Capacity: 262 MW

Lamar, CO

- Turbine Size: 1.5MW
- Manufacturer: GE Wind
- Developer/Owner: GE Wind/Shell, PPM
- Capacity: 162 MW
- Commissioned: 2003

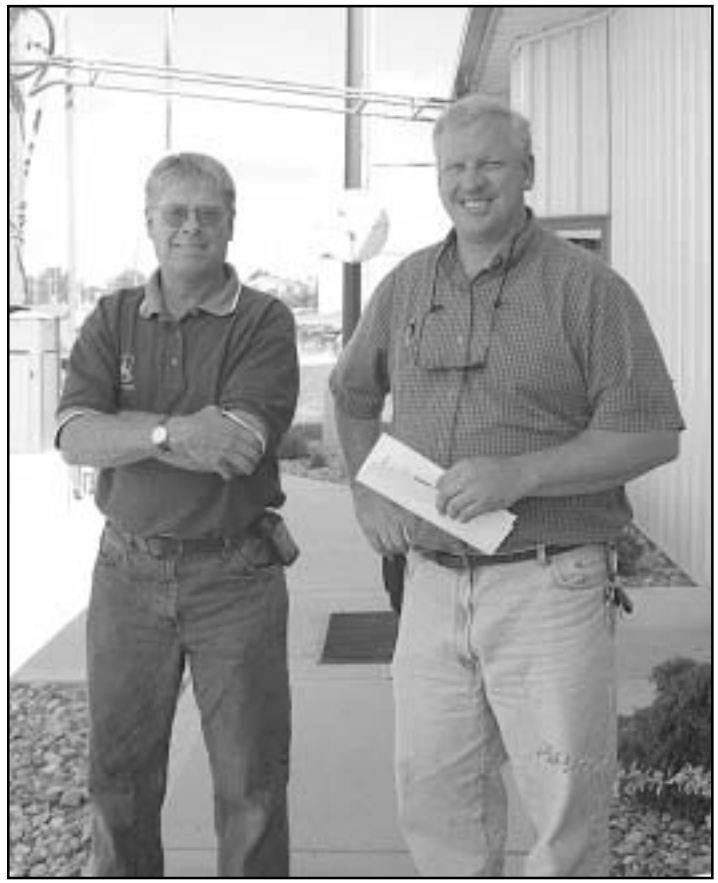
Kas Brothers Plant 25-Year Cash Crop

- First farmer owned commercial-scale project in U.S.
- Two 750 kW Micon turbines installed in summer of 2001.
- Financed with local banks (had an equity partner).
- Dozens of farmers in MN now following this model.

Richard and Roger Kas- Woodstock, MN

Minwind I and II
"Farmer Cooperative"

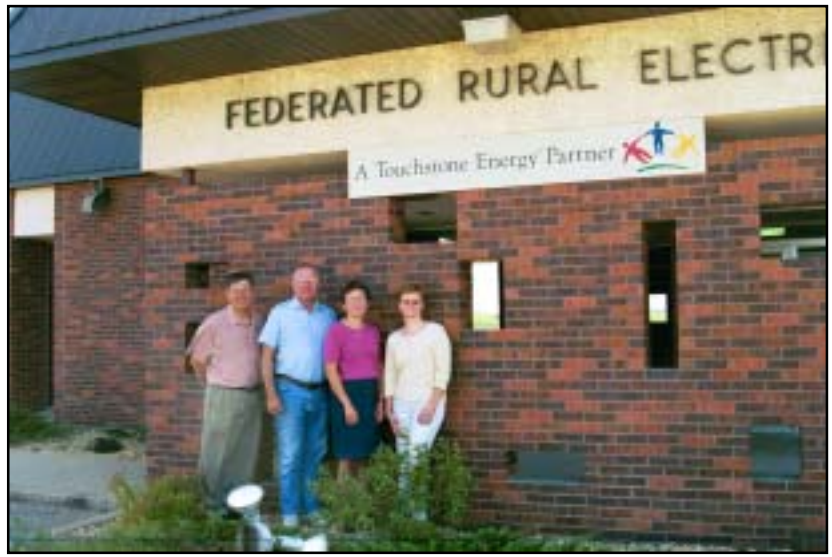
- Two LLCs formed with cooperative principles.
- Sold membership stock to 66 individuals (33 in each group, required 85% of shares to be owned by farmers)
- No individual can own more than 15% of the shares.
- Developed two 1.8 MW projects (to use MN incentive)
- Built the project in late 2002.



Tom Arends and Mark Willers,
Presidents of Minwind I and II

Rural Electric Cooperatives

- Three Rural Electric Cooperatives received USDA funds to develop wind projects:
  - Federated Rural Electric Association (MN) $500,000
  - Nobles Cooperative Electric (MN) $500,000
  - Illinois Rural Electric Cooperative (IL) $438,544



The team at Federated Rural Electric Association.
Photo by Lisa Daniels.

2003 Federal Farm Bill Awardees

$187,134 for 9 small wind projects

Small Wind Awards				
State	Grant Request	Project Size	Ownership	Application
IA	$ 10,000	10kW	Small Bus	Net Metering (grain drying)
ID	$ 10,000	20kW	Ag Producer	Net Metering
MN	$ 17,175	39kW	Ag Producer	Net Metering
MN	$ 17,110	35kW	Ag Producer	Net Metering
MN	$ 16,850	35kW	Small Bus	Net Metering
MN	$ 16,850	35kW	Small Bus	Net Metering
NE	$ 10,000	10kW	Small Bus	Net Metering
NY	$ 78,819	100kW	Ag Producer	reduce annual energy purchases, reduce operating costs, & generate additional revenue
WA/MT	$ 77,449	90kW	Small Bus	Net Metering
WA	$ 11,700	20kW	Small Bus	Net Metering

Farm Bill Utility-Scale Wind Projects

Large Wind Awards

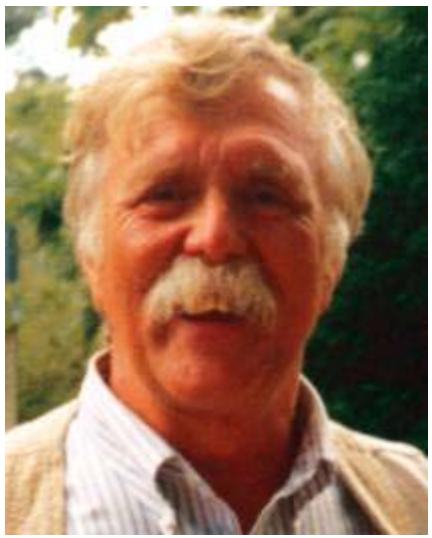
State	Grant Request	Project Size	Ownership	Application	# of Projects
MN	$192,900	1.25MW	Coop (small business)	Wholesale Power Production	5
ID	$500,000	1.5MW	Ag Producer	Wholesale Power Production	1
MN	$500,000	1.5MW	Rural Electric Coop	Wholesale Power Production	2
IL	$438,544	1.65MW	Rural Electric Coop (small bus)	distributed to coop members	1
MN	$200,000	1.65MW	Coop (small business)	Wholesale Power Production	1
MN	$178,201	1.65MW	Coop (small business)	Wholesale Power Production	7
MN	$500,000	1.9MW	Ag Producer	Wholesale Power Production	1
MA	$470,000	3MW	Coop (small business)	Wholesale Power Production	1
IA	$402,500	5.6MW	Small Bus	Wholesale Power Production	1
TX	$500,000	9.9MW	Small Bus	Wholesale Power Production	1
IL	$300,000	22.5MW	Small Bus	Wholesale Power Production	1
VA	$500,000	49.5MW	Small Bus	Wholesale Power Production	1
IA	$99,999	111MW	Small Bus	Wholesale Power Production	1

Algona, IA

- Turbine Size: 750 kW
- Capacity: 2.25 MW
- Turbine Manufacturer: Zond Corporation
- Turbine Owner: Consortium/Cedar Falls is lead with 2/3 ownership

"In my 44 years in the municipal utility business, no utility project has ever generated more customer support and interest than our wind turbine project."

Nick Scholer, former manager of Algona Municipal Utilities, Algona, Iowa



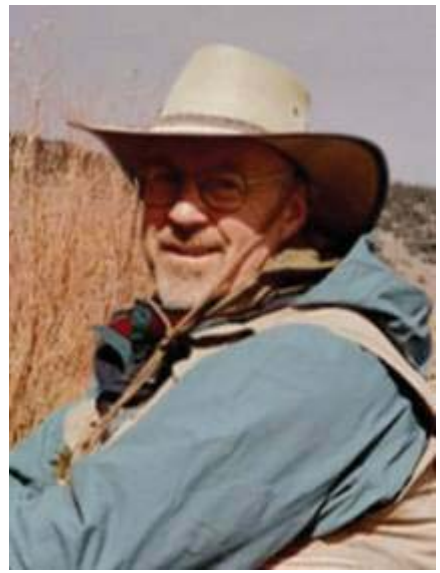
"Wind is a homegrown energy that we can harvest right along side our corn or soybeans or other crops. We can use the energy in our local communities or we can export it to other markets. We need to look carefully at wind energy as a source of economic growth for our region"

David Benson, Farmer and County Commissioner, Nobles County, Minnesota

"Wind energy adds diversity to our generation fleet and provides a hedge against fossil fuel price increases. In addition, the development of renewable energy resources is widely supported by the public and our customers."

Rick Walker, director, Renewable Energy Business Development, AEP Energy Services, Inc., Dallas, TX

WIND POWERING AMERICA



"You don't have to be a utility commissioner to see that we need better regulatory policies to achieve the diversity, economic development, and environmental benefits of wind power."

Bob Anderson, Montana Public Service Commission, Helena, Montana

Carpe Ventem

www.windpoweringamerica.gov